

Dry Powder Inhaler Devices

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Introduction

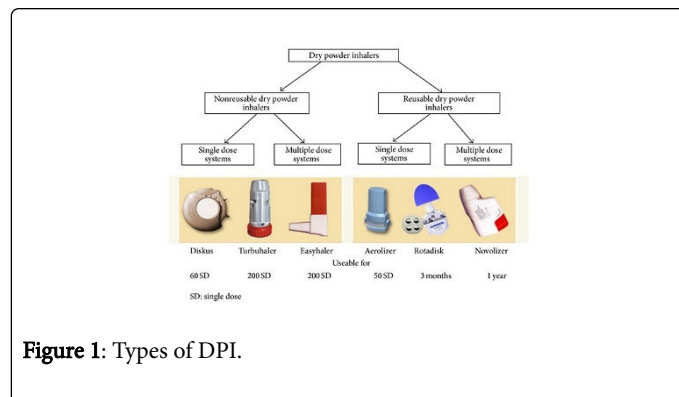
Dry powder inhaler (DPI) is a vehicle that is used to transfer drug into body. The efficient delivery of drug into the lungs depends on performance of drug delivery system and powder formulation. DPI and drug chemistry needs to fulfill safety, efficacy, bio-equivalence and reliability for product approval.

Following factors affect the performance of drug [1-4].

- Mouth piece configuration
- Mouth piece length
- Impaction angle of the powder with devices
- Air inlet size

DPIs provide alternative to metered-dose inhaler(MDI). DPI require a measured dose of powder ready to use by patient use. The drug may be held either in capsule for manual loading or installed in device and ready to use.

Once loaded the patient puts mouth piece of inhaler into their mouth and take a deep inhalation holding the amount of dose delivered is less than few tens of milligrams in a single push. Larger powder may cause cough.



Most DPIs depends on the force of patient to inhale powder from DPI. For this reason, particles that are small that are unable to reach lungs any lead to reduced drug delivery. DPIs mostly used to treat respiratory diseases e.g. asthma, bronchitis and emphysema. Recent studies show that DPI can also be used for diabetes (insulin inhaler).

Due to various design and configuration there are number of devices. However, this review covers some categories of DPI devices. Types of DPI are described in Figure 1.

Key Physical Attributes for An Inhaler Delivery System

- Easy to use

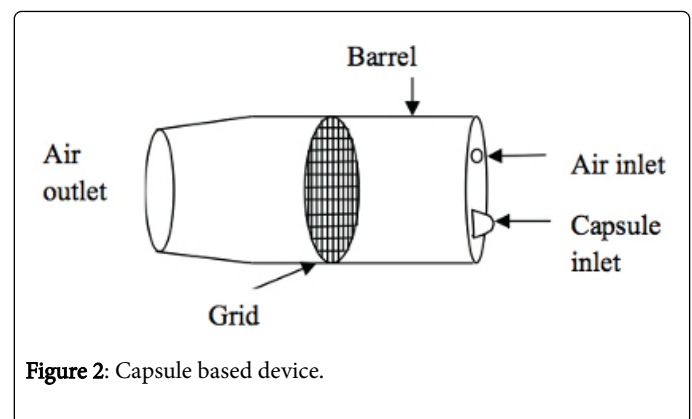
- Discreet
- Portable Visible dosing
- Easy dose loading
- Clean and hygienic
- Separate device and doses

What are Dry Powder Inhalers Used for?

DPI are commonly used for the treatment of respiratory diseases such as emphysema, bronchitis and COPD (Chronic Obstructive Pulmonary Disease) although DPI have also been used to treat diabetes mellitus as inhalable insulin. Recently FDA approves Utibron and Seebri Neohaler DPIs [5].

Capsule Based Devices

These DPI devices generally consists of a chamber where capsule is placed [6]. When patient push the button, capsule is broken by external force by the action of installed twist or pins. Powder is released and inhaled by patient (Figures 2 and 3).



Capsule based devices listed below

- Aerolizer
- Rotahaler
- ARCUS
- FlowCaps
- DOTT DPI
- Breeze haler
- Aerohaler
- Podhaler
- Redihaler
- Plastiaphe mono dose DPI

A simple capsule based consists of barrel shaped cap and body frame. There is a grid between cap and body frame. The cap has two openings one for capsule other for air when patient inhales air during aspiration. The body frame act as mouth piece during inhalation. Grid allow high speed collisions for drug particles.

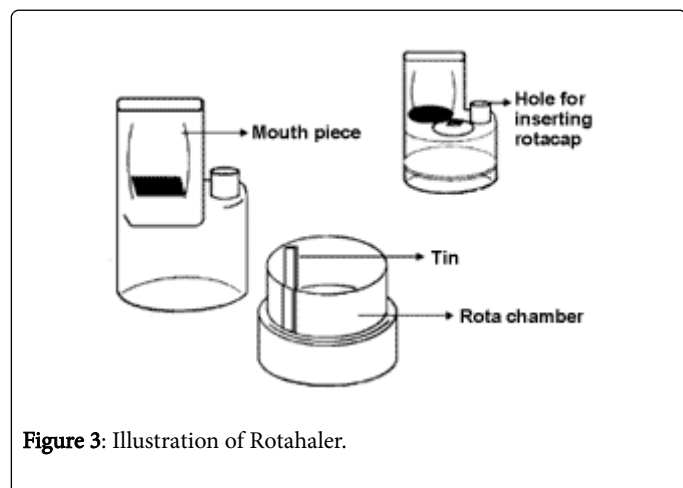


Figure 3: Illustration of Rotahaler.

There is capsule chamber in space between cap and grid. When patient twists cap and body the drug, powder is released from capsule into chamber which then enters the body during inhalation (Figure 4).

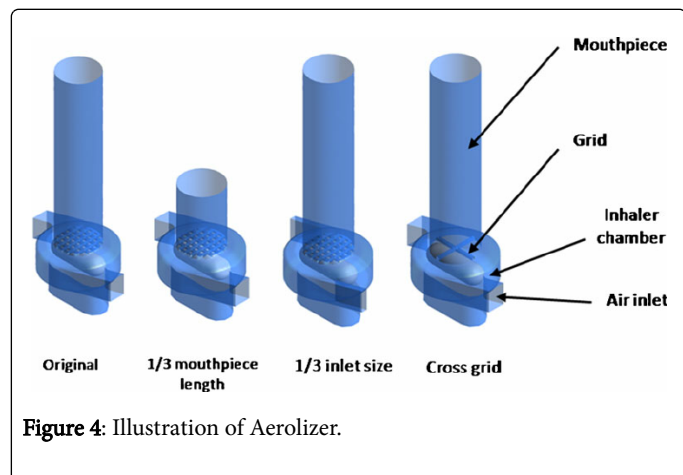


Figure 4: Illustration of Aerolizer.

Aerolizer consists of capsule chamber, air inlet, grid and mouth piece. The powder is released from capsule by piercing the capsule. It is usually used for asthma. e.g. Foradil aerolizer.

Blister Based Device

The blister based DPIs have a ring of aluminum blister inside the DPI device. Each blister contains the dose of powder drug. Dose is indicated by a dose counter installed in DPI. When the blister is burst by applying external force. Then the drug powder is inhaled by air stream when patient takes the breath [7-9].

Micro Dose DPI is an example of blister based devices. It has a piezo electric vibrator that converts electrical energy to mechanical motion. A blister is bursts before patient breathe. Activation of this vibrator depends on threshold level of air flow inhaled by patient.

The vibrator pierced the blisters and release the drug to be inhaled by patient. Micro dose has been developed specially for pulmonary delivery of drugs (Figure 5).

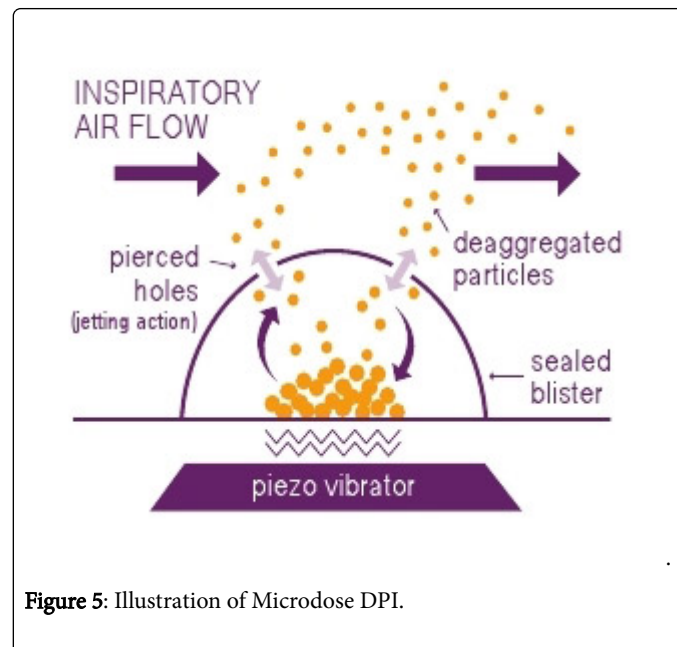


Figure 5: Illustration of Microdose DPI.

Inhaled atropine is being developed as a systemic and pulmonary treatment for the extended recovery period after chemical weapons exposure. Micro dose DPI is used for delivery of Atropine.

Some of blister based inhaler devices are listed below

- Acu Breathe
- Aspirair
- Diskhaler
- Diskus
- Forspiro
- Gyrohaler
- Meadwest Vaco
- Microdose DPI
- Pro haler
- Votran DPI

Cartridge Based Device

These devices have a powder chamber to store drug powder. The device has special mechanism to release drug on inhalation.

Following are some cartridge based devices [10-12].

- Xectovair
- Ultrahaler
- Spiromax
- Swinghaler
- PADD
- Jethaler
- E flex
- Pulmojet
- VIP inhaler
- NEXThaler

Novolizer is example of cartridge based device. It has a button connected with a push lever is connected with a bar that is linked with the powder chamber. It can be used multiple times (Figure 6).

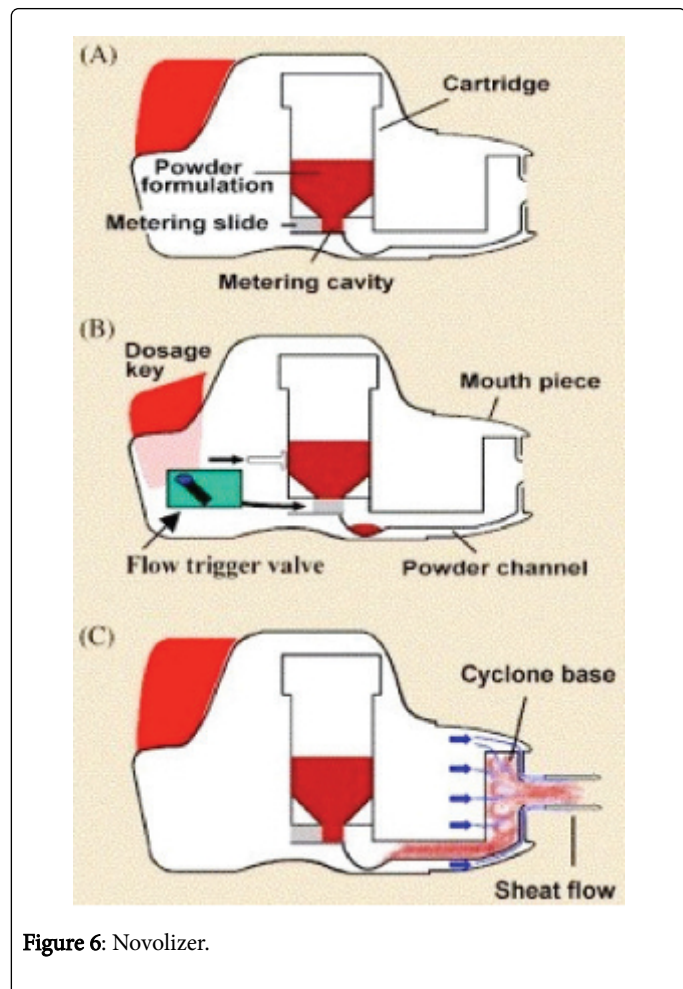


Figure 6: Novolizer.

DPI Instruction

- Health care must provide technique appropriate to use device.
- Different devices require different techniques to use.
- Nebulizer should be washed after every use.
- Different dosage is required for different diseases and different patients.
- Since every patient has different lung capacity its assure that require dose is set with the help of dosage meter. This dosage directly depends on efficiency of patient to absorb drug.
- Do not bite or chew on the mouthpiece
- You may not taste, smell or feel the medication but this does not mean you did not get the medication.

DPI Problems

- DPI irritation may cause cough
- High moisture may cause clumping of powder.
- Blowing into DPI may blow drug out and induce internal humidity.
- Different inhalation pattern MDI (Metered dose inhaler)

Inhalation flow (Table 1)

DPI	Pros	Cons
Capsule DPIs (Aerolizer and Cyclohaler-note the HandiHaler is only licensed for COPD so is not considered here)	Formulation is protected from moisture	Need to insert the dose before use need to use two separate inhalations for each dose patients need to inhale as fast as they can for as long as they can highly likely that there is dose remaining in the capsule even after the second inhalation low resistance so patients may inhale too fast resulting in high oropharyngeal impaction and low lung deposition patients have more problems using these compared to other DPIs
Low-resistance DPIs (Accuhaler, Diskhaler, Novolizer)	Easy to achieve a fast inhalation flow good protection from moisture dose counter	If patient deteriorates Novolizer requires a minimum inhalation flow to emit a dose be higher and lung deposition usually lower than other DPIs inhalation flow likely to decrease inhalation flow may be too fast
Medium-/high-resistance device	Low inhalation flows reduce oro-pharyngeal flow and increase lung deposition good distribution throughout the airways overall reduced inter- and intra-patient variability dose counter	Doses stored in a reservoir inside the device moisture protection patients may have problems achieving the required minimum inhalation flow

Table 1: Pros and cons of different dry powder inhalers.

Conclusion

DPI is fast growing area. These devices play key role in efficient inhalation of drug and provide quick intake of drug. This review covers basic information regarding DPIs and their mechanism detailed information can be found from patents.

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